

VEGETATION CHANGE IN YOSEMITE VALLEY,
YOSEMITE NATIONAL PARK, CALIFORNIA,
DURING THE PROTOHISTORIC PERIOD

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ABSTRACT

The sediments of Woski Pond, Yosemite Valley in Yosemite National Park, record paleoenvironmental change spanning the last 1550 years. Closed conifer forest, consisting primarily of ponderosa pine, white fir, incense-cedar and Douglas-fir, existed around the pond until ca. 650 years ago. After 650 years ago more open canopy vegetation types such as oaks, sage and shrubs were found. Ethnographic records taken at the time of contact indicate that the aboriginal inhabitants regularly burned the Valley. The rapid decline in pine and increase in oak, coupled with elevated charcoal concentrations, indications of increased erosion and great expansion of aboriginal populations and cultural technologies are highly suggestive of vegetation manipulation for increased food resources by the early inhabitants of the Valley. These findings have implications for management of assumed natural vegetation types.

Until recently the number and coverage of sites with paleoecological information within the Sierra Nevada has been inadequate to answer basic questions regarding Holocene vegetation changes (Adam 1985). Adam (1967) was among the first to examine vegetation history within the central Sierra Nevada. Successive studies were not conducted for nearly two decades after his pioneering work (Cole 1983; Anderson et al. 1985; Davis et al. 1985; Davis and Moratto 1988; Smith 1989; Anderson 1990).

Though Yosemite National Park has been a focus for recent paleoecological reconstructions (Smith 1989; Anderson 1990), including palynological investigation of archeological sites at high elevations (Adam 1967), the history of vegetation change at low elevations in the more developed portions of the Park has been largely ignored. We present here the results of the first study to document long-term vegetation changes within Yosemite Valley, being part of a multidisciplinary ecological/archeological investigation. Suitable deposits for paleoecological studies are rare within Yosemite Valley, but are

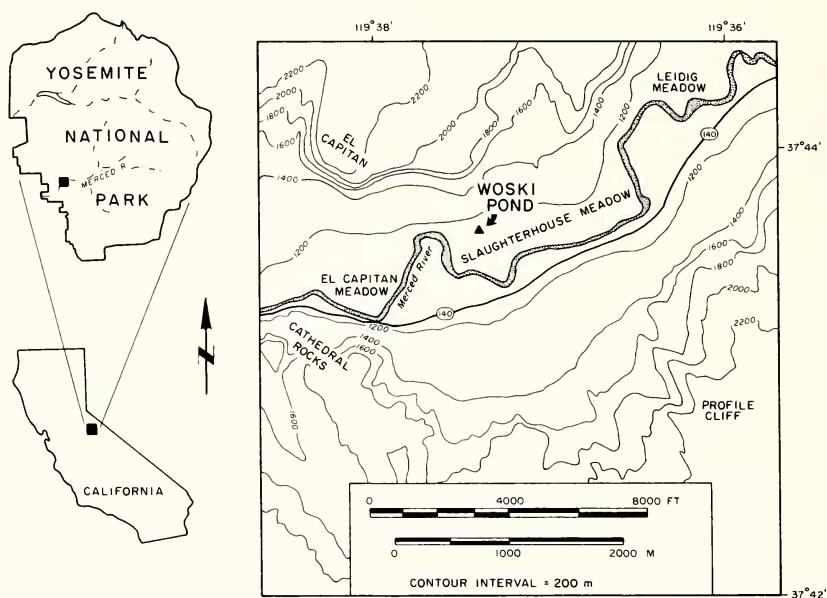


FIG. 1. Location of Woski Pond in Slaughterhouse Meadow, Yosemite National Park, California.

found at Woski Pond, a small oxbow depression on the Merced River floodplain (Fig. 1). The record covers the last ca. 1500 years, a period of considerable climatic change and expansion of human populations and related cultural systems within the area.

Three hypotheses for the major vegetation changes within Yosemite Valley that began ca. 650 yr BP will be presented. One hypothesis suggests that the forest associations were modified and exploited by the early aboriginal peoples inhabiting the Valley, subsequent to a major fire within the area. A second hypothesis relates the changes to possible climatic perturbations alone. A third alternative hypothesis suggests that geomorphic processes occurring along the floodplain of the Merced River caused the vegetation change.

STUDY AREA

The climate of the western Sierra Nevada is mediterranean, with cool, wet winters and warm, dry summers. Mean January and July temperatures in Yosemite Valley are ca. 5°C and 22°C, respectively; mean precipitation during January and July is 16.8 cm and 0.9 cm, respectively (NOAA 1980). Most precipitation comes from storms

originating in the Pacific Ocean and moving eastward. However, some moisture comes from summer convection storms.

Woski Pond itself (1212 m) is a small (ca. 0.1 km) cut-off meander on the floodplain of the Merced River (Fig. 1). It is located in Slaughter House Meadow at the base of El Capitan (37°43'30"N, 119°37'30"W). In most years, the depression contains standing water through much of the summer dry season. However, when visited in September 1986 only a marshy area was apparent.

The surficial geology of the area has been studied for a long time. Much of the valley is underlain by lacustrine sediments and glacial outwash deposited in moraine-dammed lakes during the waning stages of Wisconsin and pre-Wisconsin age glaciations (Matthes 1930). Maximum thickness of these deposits approaches 600 m (Gutenberg et al. 1956).

Modern vegetation within the valley today is mixed woodland and yellow pine forest (Munz and Keck 1959). Woody species include ponderosa pine (*Pinus ponderosa*), incense-cedar (*Calocedrus decurrens*), California black and scrub oaks (*Quercus kelloggii* and *Q. dumosa*), white alder (*Alnus rhombifolia*), western raspberry (*Rubus leucodermis*), and blue elderberry (*Sambucus caerulea*). Riparian woody plants include black cottonwood (*Populus trichocarpa*) and willows (*Salix* sp.). The marsh and meadow surfaces are covered by grasses, sedges and rushes, along with *Mentha arvensis*, *Agastache urticifolia*, *Rumex* cf. *angiocarpus*, *Alisma triviale*, *Viola macloskeyi*, *Ranunculus flammula*, *Equisetum arvense*, *Pteridium aquilinum*, several members of the Asteraceae, and others.

Woski Pond is within the immediate vicinity of several pre- and protohistoric archeological sites, occupied at various periods during the past 2000 to 3000 years. Excavations indicate a myriad of uses including habitation, resource procurement, tool manufacture, and food processing. The greater Yosemite Valley area would have provided an abundant array of plant and animal resources useful to the human populations.

METHODS

A 260-cm long sediment core was collected from the marsh surface on 13 September 1986, using a modified 5-cm ID Dachnowsky corer (Faegri and Iversen 1975). Twenty-two subsamples for pollen and microcharcoal were taken at 8–20-cm intervals along the core length. These were subjected to standard palynological processing techniques (Faegri and Iversen 1975), including addition of *Lycopodium* tracer spores for calculation of pollen concentration. The resulting pollen assemblage was mounted in silicone oil and individual grains were identified by comparison with the pollen and spore reference

collection at the Department of Geosciences, University of Arizona, as well as from personal collections. Usually 300 grains exclusive of spores and aquatic pollen were counted. In most cases this consisted of counting at least 100 non-*Pinus* grains. Two size fractions of charcoal particles were tallied. Microcharcoal particles were tallied from the pollen preparations by measuring the amount of charcoal on the pollen transects (Anderson et al. 1986). Eleven half-core segments of various lengths (4–8 cm) were gently sieved with water through standard soil sieves (0.212 mm and 0.850 mm) to disaggregate the macrofossils and macrocharcoal. Macrocharcoal particles were counted from the macrofossil preparations. These were not measured but were tallied individually.

RESULTS

Sedimentology and radiocarbon dates. The top 215 cm of the core consisted of organic silts, with decreasing organic content downcore (Fig. 2). Wood fragments were abundant from 10 to 18 cm, 142 to 147 cm and at 178 cm. Silts and sands occurred between 18 and 26 cm. Coarse decomposed granitic sands with abundant muscovite occurred from 215 to 229 cm, with finer gray sands to the core bottom.

Three bulk-sediment radiocarbon dates were in stratigraphic order, with the oldest being 1440 ± 90 yr BP (Table 1). Sediment accumulation rates were calculated as follows: 0–46 cm, 0.080 cm/yr; 46–123 cm, 0.513 cm/yr; below 123 cm, 0.118 cm/yr.

Palynology and paleobotany. Two fossil assemblage zones were recognized, based on changes in the pollen (Fig. 3), plant macrofossil (Fig. 4) and aquatic fossil diagrams (Fig. 5). Zone I contained sediments deposited between ca. 650 and 1550 yr BP (between 85 cm and the core bottom), and was subdivided into two subzones. Zone II spanned the most recent ca. 650 years (the upper 85 cm of the record). At least 77 pollen and spore types were recognized, only the most common of which are shown in the diagrams. The pollen sum was composed of all upland pollen types. Pollen preservation was generally good; degraded percentages varied from 1.9 to 17.8% of the sum. However, Zone II pollen assemblages were consistently more poorly preserved than those of Zone I (see below).

Arboreal pollen types dominated during Zone I time. Pine pollen was consistently 60 to 75% of the sum. Macrofossils of ponderosa pine, lodgepole pine (*Pinus murrayana*) and Douglas-fir (*Pseudotsuga menziesii*) were found (Fig. 4). Fir (*Abies*) pollen was generally >3%, and fir needle fragments were found. TCT (Taxodiaceae-Cupressaceae-Taxaceae) pollen was variable, but centered around 6 to 7%. Leaves of *Calocedrus decurrens* were common in these sediments. Oak pollen centered around 6%, and mountain hemlock

WOSKI POND, CA. STRATIGRAPHY

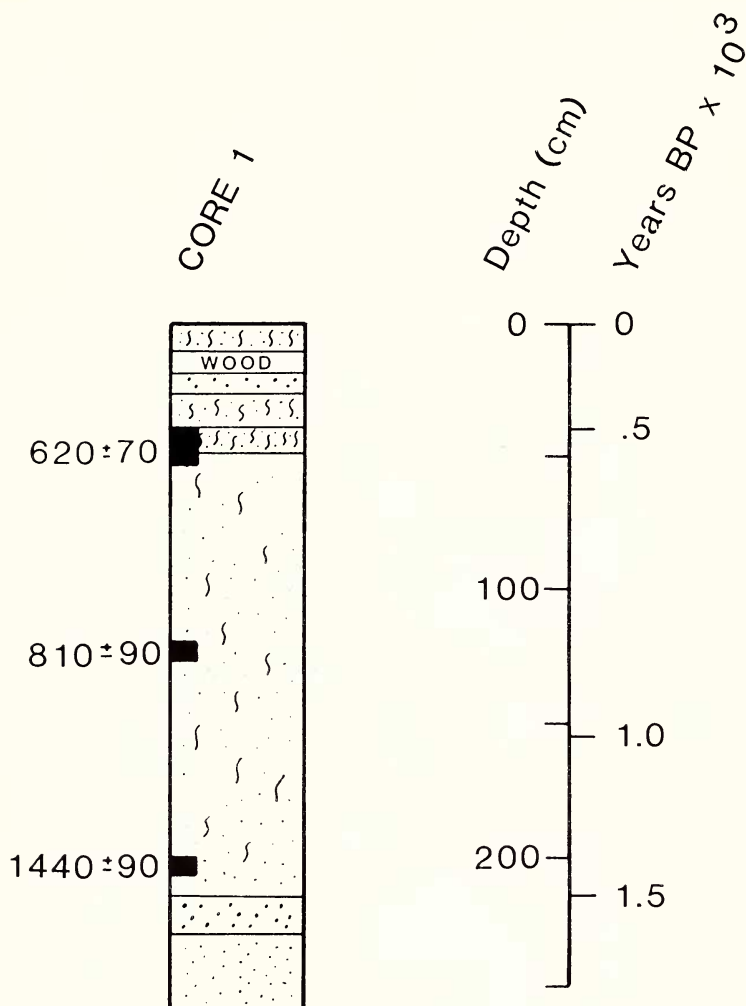


FIG. 2. Stratigraphy of the Woski Pond core. Symbols are: light dots = silts; heavier dots = sands; sigmoid symbol = organics.

(*Tsuga mertensiana*) pollen was consistently represented. A parasite primarily on conifers, mistletoe (*Arceuthobium*) pollen was found only during Zone I. Shrub pollen types were not as abundant as in the succeeding zone, with the exception of *Ceanothus*. Several herbs indicative of meadow or moist areas were common: *Gilia*, *Thalictrum*, *Polygonum bistortoides* and *Eriogonum*.

TABLE 1. RADIOCARBON DATES ON WOSKI POND SEDIMENTS.

Depth (cm)	Lab no.	¹⁴ C Date (yr BP)	With ¹³ C adjustment (yr BP)
40-53	Beta-18362	620 ± 70	580 ± 70
120-127	Beta-18363	810 ± 90	730 ± 90
200-207	Beta-18364	1440 ± 90	1410 ± 90

Charcoal abundance was greatest within Zone I (Figs. 3 and 4). However, maximum amounts occurred at the Zone boundary, in association with a decline in coniferous elements.

Macrofossils of wetland or riparian trees and shrubs, such as *Populus*, *Salix* and *Alnus*, were most abundant in Zone I sediments (Fig. 5). Common herbaceous plants included *Isoetes* (subzone Ia), as well as *Potamogeton* sp. and sedges (both subzones Ia and Ib).

Arboreal pollen types also dominated the Zone II spectra, but with differing importance. Pine (35 to 52%; *P. ponderosa* macrofossils only), fir (ca. 1 to 2%), and mountain hemlock pollen types declined, with a complete absence of mistletoe pollen. Instead, increases in oak (6 to 13%) and TCT (mostly *Calocedrus* here; generally above 9%) occurred. Shrub pollen types were more abundant, including *Cercocarpus*-type, *Prunus*-type, and *Sambucus*. Common herbaceous types included *Rumex*, grasses, *Pteridium aquilinum*, and trilete spores, among others. Charcoal concentration and influx was much reduced in Zone II over values for Zone I. In the aquatic fossil assemblage, only *Alisma triviale* was more abundant during Zone II.

DISCUSSION AND CONCLUSIONS

For reconstruction of former vegetation from pollen assemblages, we utilize the modern pollen studies of Anderson and Davis (1988) and Adam (1967). The sediments of Woski Pond record paleoenvironmental change for the lower Yosemite Valley, spanning the last 1550 years. In total, the record indicates that regional vegetation has not changed significantly during the time of deposition; most fossil types identified to species can be found growing in the valley today. However, the record does suggest that significant local changes in the importance of individual species have occurred.

A closed conifer forest probably existed around Woski Pond during Zone I, based on higher pollen percentages of pine, fir, Douglas-fir, and mistletoe, along with the regular occurrence of ponderosa pine and Douglas-fir needles. The pond was surrounded by riparian species, such as *Populus trichocarpa*, *Salix* sp., and *Alnus rhombifolia*. After ca. 650 years ago, however, more open canopy vegetation

WOSKI POND, CALIFORNIA, POLLEN PERCENT

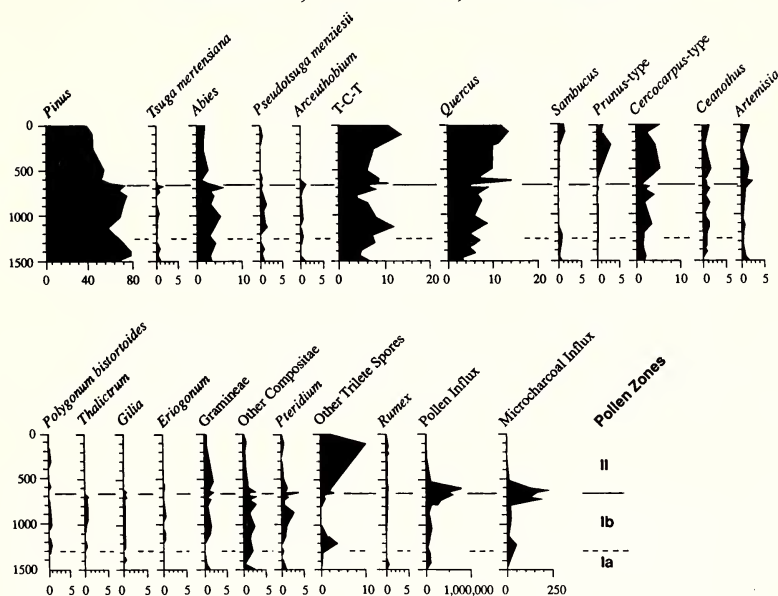


FIG. 3. Summary diagram of terrestrial pollen percentages from the Woski Pond core. Included are curves for pollen influx (grains/cm²/year) and microcharcoal influx (mm²/cm²/year).

types such as oaks, sage, and the shrubs *Prunus* and *Sambucus* were favored. Few riparian trees surround the pond today, and their fossil record is diminished throughout Zone II.

The charcoal record, an indicator of fire occurrence, largely parallels the ponderosa pine macrofossil record. Abundant needle remains are associated with higher charcoal concentrations and influx in Zone I than Zone II, with maximum charcoal values at the zone boundary, ca. 650 yr BP. This suggests that the factor largely controlling the abundance of charcoal in the sediment (i.e., fire in the environment) is the local presence of this major conifer. The greater biomass provided by closed conifer forest would produce larger amounts of charcoal when burned.

The major change in pollen assemblages begins ca. 700 yr BP, with a decline in conifers and an increase in oak. Peaks in both charcoal, pollen, and sediment influx occur contemporaneously, indicating a period of erosion. These factors taken together suggest a major vegetation disturbance at that time.

Climatic change is a possible cause of the vegetation shift. Little Ice Age cooling within the Sierra Nevada (the Matthes glaciation of Burke and Birkeland 1983) commenced near that time. Evidence of

WOSKI POND, CALIFORNIA, MACROFOSSILS

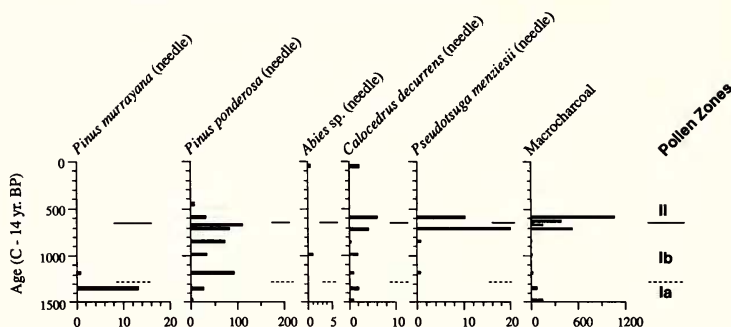


FIG. 4. Summary diagram of macrofossil influx (mm/cm²/year) for dominant conifers found in the Woski Pond core.

lowered upper elevational tree limits (LaMarche 1973; Scuderi 1987; Anderson 1990) point to climatic change. However, the effect of climatic cooling with increased effective precipitation should have had an effect directly opposite the observed change, favoring an increase in conifers, especially fir (Anderson 1990). Somewhat conflicting evidence is indicated from tree-ring data, suggesting slightly drier winters than present near Kaiser Pass, southern Sierra Nevada (2700 m elevation), beginning by ca. 1300 AD and lasting for ca. 50 years (Graumlich 1990). Although climatic change may have been a contributing factor, neither the tree-ring nor glaciological evidence can fully account for the abrupt vegetation changes noted at Woski Pond.

Another explanation for this rapid shift in vegetation composition is the occurrence of a local, catastrophic event caused by human or other natural factors. The effect of pre-modern human activity on the natural environment, as registered in sedimentary deposits, has been well-documented, especially for Europe (Iversen 1941; Bonatti 1970; Pilcher et al. 1971; Behre 1981), but also for North America (McAndrews 1976; Betancourt and Van Devender 1981; Burden et al. 1986; Delcourt et al. 1986; O. K. Davis and Turner 1987; Cinnamon 1988; Byrne and Horn 1989).

Yosemite Valley has been occupied by humans for at least the past 3000 years (Mundy and Hull 1987). Throughout the late Holocene, distinct changes have occurred delimiting successive cultural systems. Over 100 archeological sites are found in Yosemite Valley, spanning the Crane Flat, Tamarack and Mariposa cultural complexes (Carpenter 1984, 1985a; Mundy and Hull 1987). Changes in stone tool production and use, resource procurement, trade and other cultural traits depict a shift in lifestyle from seasonal hunting and

WOSKI POND, CALIFORNIA, AQUATICS

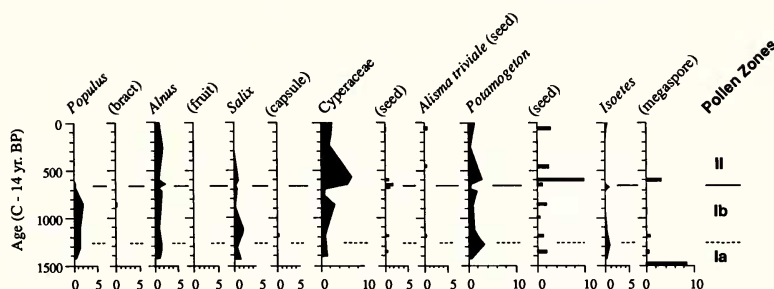


FIG. 5. Summary diagram of aquatic pollen percentages (silhouettes; outside the pollen sum) and macrofossil influx (bars; numbers/cm²/year) for the Woski Pond core.

gathering within the Crane Flat and Tamarack complexes, to more sedentary occupation characteristic of the Mariposa complex, with increased reliance on oak acorns for consumption and trade.

If the rapid shift in vegetation composition was instigated by fire, as suggested by the large charcoal peak, it cannot be determined whether this was accomplished by aboriginal populations or lightning ignition. However, the correlation between the increase in charcoal, the change in dominant pollen from pine to oak, and the transition in cultural systems from the Tamarack to the Mariposa complex (Moratto 1984) all occur at ca. 650–750 yr BP. The Mariposa cultural sequence included an increase in population and development of specialized economic and resource-procurement systems, including the development of and reliance on various horticultural techniques (K. Anderson pers. comm. 1990). Manipulation of the natural environment by clearance of the conifers within the valley would have favored expansion of oaks, the acorns of which were a major food resource for these people.

Ethnographic evidence provides support for the vegetation manipulation hypothesis. Once the land was cleared, the early inhabitants of Yosemite Valley (Sierra Miwok) and other California locations regularly used fire and other physical means to keep the forest in an open state (Lewis 1973; Wickstrom 1987). Galen Clark, longtime caretaker in Yosemite, wrote in 1894 that the Indian policy of management “was to annually start fires in the dry season of the year and let them spread over the whole valley to kill young trees just sprouted and keep the forest groves open and clear of all underbrush, so as to have no obscure thickets for a hiding place, or an ambush for invading hostile foes, and to have clear grounds for hunting and gathering acorns. When the forest did not thoroughly

WAWONA MDW, CALIFORNIA, POLLEN PERCENT

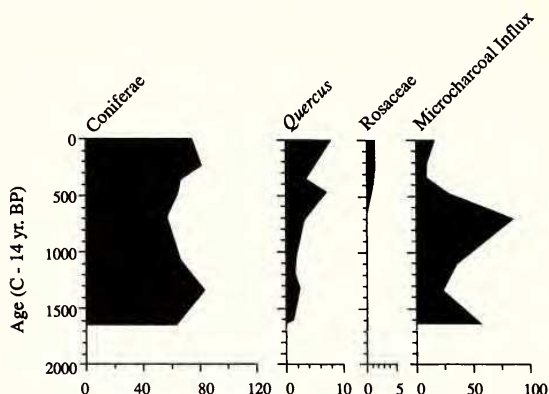


FIG. 6. Selected pollen types from the Wawona Meadow, Yosemite National Park, core. Conifers include *Pinus*, *Abies* and TCT (mostly *Calocedrus*); Rosaceae includes *Prunus* and *Rubus*. Microcharcoal influx is measured in $\text{mm}^2/\text{cm}^2/\text{year}$.

burn over the moist meadows, all the young willows and cottonwoods were pulled up by hand” (Ernst 1949). If these practices were typical also of the protohistoric Sierra Miwok, we can hypothesize a series of events leading to vegetation change within the valley. These include 1) a major fire that cleared many conifers out of the valley, and 2) subsequent regular but lighter fires and active eradication to keep the young pines from regenerating. The reduction in sedimentary charcoal during most of Zone II (Fig. 4) may be a result not of a lack of ignition but, instead, a reduction in fuel loads caused by these periodic aboriginal burns within the valley. It would also explain the major pollen changes beginning ca. 650–750 yr BP.

Additional support occurs in the pollen and charcoal stratigraphy of a core from Wawona Meadow, southeastern Yosemite National Park, at similar elevation to Woski Pond. Sampling is not as detailed as at Woski Pond; however, a major charcoal peak occurs at an interpolated age of ca. 700 yr BP (Fig. 6). Increases in pollen of oak and Rosaceae follow the charcoal peak. Over 60 archeological sites are recorded within the Wawona area, with ethnohistoric and archeological research indicating comparable cultural patterns as those known for Yosemite Valley (Hull 1989; Carpenter 1985b; Ervin 1984).

An additional alternative explanation for the changes at Woski Pond involves possible hydrological changes on the Merced River floodplain. Support for this hypothesis includes the persistence of pollen of typically higher elevation trees, such as mountain hemlock and fir, in sediments of Zone WP-Ib, possibly water-borne. The

increase in oak and other pollen types in WP-II could be a result of decreased input of river-borne pollen (Adam pers. comm. 1990). This, however, does not explain similar changes in pollen stratigraphy at Wawona Meadow, where stream-borne pollen is unimportant.

This paleoecological perspective on vegetation change contains implications for management of fire and other disturbances within national parks. Heady and Zinke (1978) produced matching photographs of Yosemite Valley taken at European contact and in more modern times. At contact, much of the valley was an open oak-grassland with few conifers. However, after nearly three-quarters of a century of fire suppression or exclusion, the valley was choked with shrubs and young conifers; the sedimentary record also suggests a recent increase in coniferous elements (Fig. 4). Yet, which of the above conditions represents the more "natural" state? If we are correct in our conclusions regarding aboriginal manipulation, neither of these snapshots is representative of the vegetation conditions that would have occurred without human interference. The record from Woski Pond should provide ample incentive to modern ecologists to exercise caution when assuming that observed vegetation of a region is "natural", when in fact, the region has probably undergone significant human disturbance.

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